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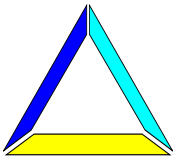

V5

Macroeconomic impact of gas price shock

Summary

Being one of the most energy inefficient countries in the Europe, Ukraine has to import most of energy resources it needs. It makes the country extremely vulnerable to energy price shocks. It is especially true for gas that constitutes almost a half of total primary energy supply in Ukraine.

In this paper we consider the impact of increased gas price resulted from January 2006 agreement signed by Naftogaz Ukrainy, Gazprom and RosUkrEnergo. Using a computable general equilibrium (CGE) model, we analyzed the macroeconomic impact of the price shock and estimated necessary reduction in gas consumption that could be sufficient to compensate for increased prices.

According to the model results, *ceteris paribus* the current gas price increase could lead to a 5.5% cumulative reduction of real GDP within medium-term horizon, being the most painful for production of chemicals, plastics and rubber, for metallurgy and for industries that supply inputs for above-mentioned sectors. To compensate the increase in gas prices, economic agents have to introduce energy-saving technologies allowing decrease in energy intensity of the GDP by approximately 12%. The possible scenario is a reduction of gas consumption by approximately one third.

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1 Introduction

Being one of the most energy inefficient countries in the Europe, Ukraine has to import the lion share of energy resources it needs. It makes the country extremely vulnerable to energy price shocks. It is especially true for gas that constitutes almost a half of total primary energy supply in Ukraine, only slightly more than a quarter of which is produced domestically.

Before January 2006 gas imports from Russia have been linked with gas transit services which Ukraine provided for Russian gas exports to Europe. For that Russia supplied gas to Ukraine. The rest of necessary gas balance Ukraine purchased directly in Central Asian countries, agreements which also envisaged in-kind payments. The January 2006 agreement[1] signed by Naftogaz Ukrainy, Gazprom and RosUkrEnergo introduced a completely new system of gas trade and transport. First, the link between gas transit and gas supply to Ukraine was broken. Second, RosUkrEnergo became the monopolist supplier of both Russian and Central Asian gas to Ukraine. Third, and most important, gas price was sharply increased.

The latter change is in the focus of this paper. Here, we make an attempt to estimate the macroeconomic effects of increased gas prices using the computable general equilibrium (CGE) model as instrument of our analysis[2]. Also, we estimated the necessary reduction in gas consumption, i.e. introduction of energy-saving technologies that could be sufficient to compensate for increased gas prices.

The rest of the paper is organized as follows. Section 2 briefly describes energy balance of Ukraine. Next, Section 3 presents scenarios used for the CGE simulations. Section 4 discusses results of simulation, including the estimate of required compensatory reduction in gas consumption. Section 5 concludes.

2 Energy balance of Ukraine

Ukraine is known as the most energy intensive countries in the Europe (Figure 1)[3]. In 2002, according to World Bank estimates[4], the energy intensity in Ukraine is 22 times higher than in Germany on the GDP basis, and approximately 4 times higher than in Germany on purchasing power parity basis. Moreover, it is almost a half higher than energy intensity of energy-resources abundant Russia if estimated on the GDP basis.

Gas dominates among various sources of energy used in Ukraine. It constitutes almost 47% of total primary energy resources supplied in Ukraine, followed by coal (29%) and crude oil (21%). While crude oil is 100% used by petroleum refineries, gas is widely used by all sectors of the economy (Table 1). In particular, electricity and heat plants consume approximately 45% of gas supply,

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[1] Detailed discussion of economic aspects of the agreement is provided in IER/GAG policy paper V4 **"**The Ukrainian-Russian gas agreement: An economic assessment"

[2] Since the CGE model is built on assumptions like perfect factor mobility and mandatory fiscal and trade balances, the result of the study should be taken with caution and considered as indicative.

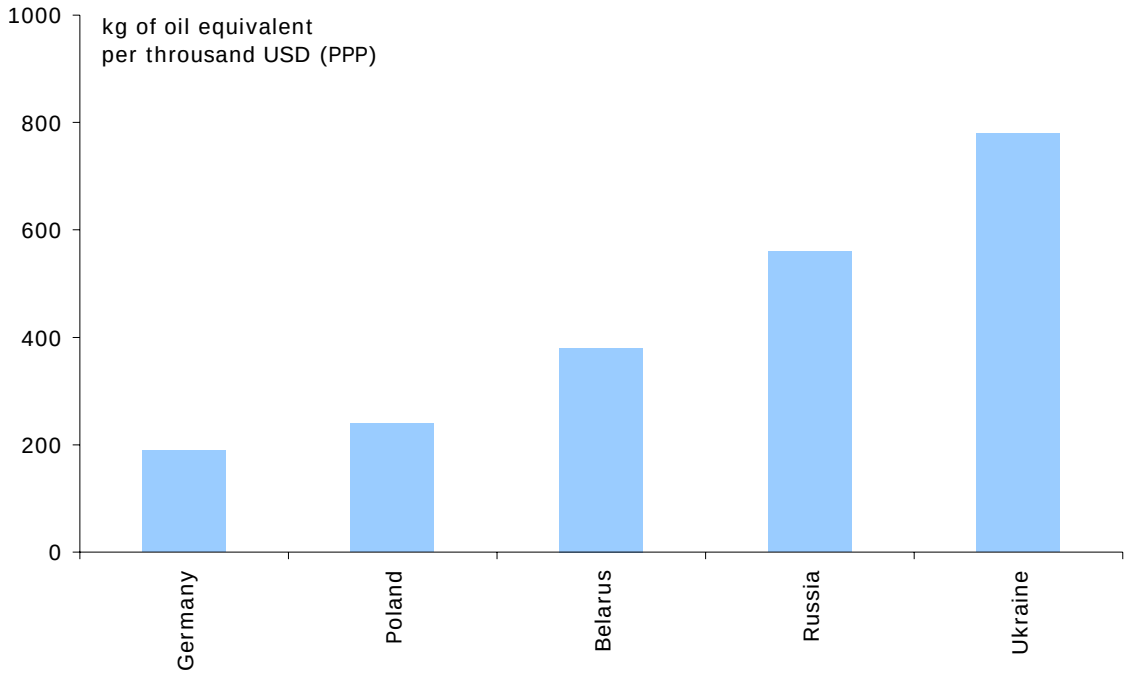
[3] For other studies of energy intensity in Ukraine see *Ukraine and the World Economy: Risk Assessment and Policy Recommendations* and *Towards Higher Standards of Living: An Economic Agenda for Ukraine* at http://www.ier.kiev.ua/English/books_eng.cgi

[4] Ukraine. The Impact of Higher Natural Gas and Oil Prices. The World Bank, December 6, 2005

while 51% of gas supply is directed for final consumption. Here, the gas is shared by households consumption (almost 21% of primary gas supply in thousand tones of oil equivalent), industrial consumption and commercial and public services. Among industries, primary consumers of gas are metallurgy and chemical industry.

Figure 1
Energy intensity of GDP for selected countries:

total primary energy supply per thousand USD of GDP



Source: IEA (2002): Key world energy statistics.

Table 1
Energy Balance of Ukraine for key products in 2003, demand side

(% of total primary energy supply measured in thousand tones of oil equivalent)

CONSUMPTION	Coal	Crude oil	Gas
Total primary energy supply	100.0	100.0	100.0
Statistical Differences	-1.9	0.0	0.0
Electricity Plants	-7.8	0.0	-25.8
CHP Plants	-32.8	0.0	0.0
Heat Plants	-6.6	0.0	-19.0
Petroleum Refineries	0.0	-100.0	0.0
Coal Transformation	-25.4	0.0	0.0
Own Use	-0.3	0.0	-2.2
Distribution Losses	0.0	0.0	-2.3
Total final consumption	25.4	0.0	50.7
Industry sector	19.7	0.0	18.3
Residential consumption	5.7	0.0	20.8
Other sectors	0.0	0.0	11.6

Source: IEA

At the same time, domestic supply of energy resources in Ukraine is quite limited (Table 2). According to the IEA, Ukraine is reasonably self-sufficient only in supply of coal, the domestic production of which covers more than 90% of total primary coal supply. At the same time, domestic production of gas is at 28% of primary supply, forcing Ukraine to import the rest.

Table 2
Energy Balance of Ukraine for key products in 2003, supply side

(% of total primary energy supply measured in thousand tonnes of oil equivalent)

SUPPLY	Coal	Crude oil	Gas
Production	92.5	15.6	27.8
Imports	14.1	90.4	80.0
Exports	-6.6	-6.0	-7.7
Total primary energy supply	100.0	100.0	100.0

Source: IEA

Key sources of gas imports for Ukraine are Russia and Central Asia countries, namely Turkmenistan, Uzbekistan and Kazakhstan (Table 3). Moreover, recently the role of Turkmenistan in gas imports has significantly increased. However, as Central Asian gas can be supplied to Ukraine only through Russia, the latter is *de facto* strategic supplier of gas to Ukraine.

Table 3
Gas imports, % of trade weight

	2000	2001	2002
Russian Federation	66.4	51.0	48.5
Turkmenistan	29.9	44.4	49.2
Uzbekistan	3.6	4.6	0.3
Kazakhstan	0.1	0.0	1.9
Total	100.0	100.0	100.0

Source: UN ComTrade database, author's estimates

3 Model scenarios

To estimate the impact of changed gas price on Ukraine's economy we use the computable general equilibrium (CGE) model for Ukraine[5]. In this paper we simulate the following two scenarios:

Scenario 1 "Shock". In this scenario we consider the consequences of the price shock after the increased import gas prices is transferred to consumers. According to our estimates, the gas price will increase by 60% compared to the benchmark[6].

[5] The CGE model was developed by the consortium of Copenhagen Economics (Denmark), Institute for East European Studies Munich (Germany) and Institute for Economic Research and Policy Consulting (Ukraine) within the framework of project "Analysis of Economic Impacts of Ukraine's Accession to the WTO" (2005).

[6] The benchmark price is estimated assuming the following structure of imported gas supply: Ukraine imports from Russia 30 bcm of gas at USD 50 and 4 bcm at USD 80. Also, Ukraine imports 24 bcm at USD 68 (net of transit payments) from Turkmenistan. Thus, the weighted average benchmark price of gas is approximately USD 60. The new USD 95 gas price is assumed.

Scenario 2 "Shock + energy saving". This is a policy scenario where we simulate the necessary reduction in gas consumption that could be sufficient to compensate for the current gas price shock studied in Scenario 1[7].

The rest of the paper is devoted to description of simulation results.

4 Results of the CGE model

Before we start discussing the results of our modelling exercise in detail, several general points must be mentioned:

The time horizon of our analysis is not explicitly fixed. Rather, our model specification with e.g. flexible factor (i.e. labour and capital) market adjustments implies that scenario results describe the full adjustment of the economy after an external shock has occurred. Typically, this can be understood as a medium term perspective over 7-10 years.

All results give changes of the respective variable relative to the benchmark year of our assessment (2002). Results do not give indications concerning the adjustment path from benchmark to the new equilibrium.

The results isolate the economic impacts of gas price increase from all other events that in reality affect economic development at the same time. This includes changes in other world prices, changes in relative exchange rates of other currencies (e.g. US dollar and euro), and all other possible shocks that might occur during the same period.

Table 4
Economy-wide effects of gas price increase*

	Scenario 1: shock	**Scenario 2:** shock + energy saving
Change in real GDP, %	-5.5	0.0
Total change in welfare, %	-19.6	0.2
--- urban non-poor households	-24.2	0.4
--- urban poor households	-4.7	-1.0
--- rural non-poor households	-20.5	0.3
--- rural poor households	-2.7	-0.6
Changes in real factor wage, %		
--- skilled labour	-7.4	-0.1
--- unskilled labour	-7.3	-0.1
--- capital	-3.8	-0.5
Factor adjustment costs, %		
--- skilled labour	6.1	0.5
--- unskilled labour	10.7	0.8
--- capital	3.5	0.5
Change in real exports of goods and services, %	-8.2	0.0
Change in real imports of goods and services, %	-6.9	-0.8
Change in the shadow price of foreign exchange, %	3.1	-0.9
Energy use coefficient:		
--- for gas	1.00	0.64

Source: author's estimate

[7] The sufficient compensation is achieved when the real GDP remains unchanged as a result of gas price shock.

Note: * These results represent cumulative change over medium-term horizon (7-10 years)

As shown in Table 4, the current increase in gas price (Scenario 1) results in significant deterioration of economic development. In particular, a cumulative medium-term reduction in real GDP is estimated at 5.5%, while a welfare will drop by 19.6% cumulatively. The worsening of welfare is explained by reduction of aggregate output, first of all in gas-intensive industries, and associated with that drop in wages by 7.4% for skilled and by 7.3% for unskilled employees. Depreciation of currency provoked by higher value of gas imports does not benefit exports (the latter will drop by 8.2% cumulatively), since export-oriented industries are at the same time industries that consume the most of gas. Adjustment to a new equilibrium economy requires significant factor adjustment. In particular, 10.7% of unskilled employees and 6.1% of skilled are to change their jobs.

Among the sectors that suffered the most are chemical industry and metallurgy, as well as linked to them production of non-energy materials (e.g. iron ore) and production of coke (see Annex A for tables). Keeping all other things unchanged, the cumulative reduction of real aggregate output may reach 85% in chemical industry and 79% in metallurgy in medium-term horizon, both due to low domestic supply and exports. Taking into account that metallurgy and chemical industry account for more than one third of Ukraine's exports, it explains the most of expected export reduction.

At the same time, the economy adjusts to the shock via reallocation of resources to other sectors. In our case gains are distributed among sectors that consume less gas or gas-intensive products. These are, first of all, service sectors like hotels and restaurants, and such manufacturing industries as machinery and equipment, textile and leather, and woodworking and publishing.

The most significant welfare reduction is faced by urban non-poor households that possess both labour and capital endowments and that will suffer the most from drop in industrial production. Also, these households are primary consumers of gas supply, electricity and heat, the price for which will increase most significantly.

To compensate gas price shock, it is necessary to adopt energy-saving technologies, thus effectively reduce the demand for gas in the economy. Scenario 2 estimates by how much gas demand is to be reduced by sectors of the economy to compensate the current gas price shock[8].

As shown in Table 4, to return the real GDP to the previous level, the economy has to go into considerable structural changes, implementing energy-saving technologies and preventing the waste of energy resources. One of the possible scenarios (simulated for this paper) will be a reduction of gas use by 36%.

The realisation of this scenario will require reallocation of resources. In particular, 0.5% of skilled employees and 0.8% of unskilled will have to change their jobs. However, most of the sectors will either grow or suffer only minor reduction (see Annex A for tables).

Being significant, the structural change required to compensate for the current price shock is not outrageous. As it was shown in Section 2, Ukraine's energy intensity is the highest in Europe, thus a significant room for energy efficiency improvement exits. Moreover, the proposed reduction in gas consumption is

[8] In the paper the energy use coefficient is applied only to energy consumption by sectors of the economy, but not by households.

equivalent to approximately 12% reduction in energy intensity of the GDP, still leaving Ukraine's energy intensity at the level far above the European average.

5 Conclusions

The analysis of macroeconomic impact of gas price growth initiated by the January Russian-Ukrainian gas agreement showed that Ukraine is extremely vulnerably to gas price shock. The estimated impact of current gas price increase is a 5.5% cumulative reduction of real GDP in medium-term horizon and almost 20% cumulative drop in total welfare. The shock of gas price will be most painful for production of chemicals, plastics and rubber, for metallurgy and for industries that supply inputs for above-mentioned sectors. To adjust to a new – lower - equilibrium, 10.7% of unskilled and 6.1% of skilled workers are to change their jobs.

To compensate the increased gas price, economic agents have to introduce energy-saving technologies allowing reduction in gas consumption. One of possible scenarios is 36% reduction in gas consumption. It is equivalent to an approximately 12% reduction in energy intensity of Ukraine's GDP.

Being significant, the required structural change is not outrageous. Being one of most energy inefficient countries in Europe, Ukraine has a great potential for fast improvement if proper reforms are introduced.

Author: VM

Lector: FP

Table A1
Percentage change in real aggregate output (cumulative)

	Scenario 1: shock	**Scenario 2:** shock + energy saving
Agriculture, hunting	16.7	-1.5
Forestry	37.5	-2.2
Fishery	13.1	-1.6
Coal and peat	-40.7	0.9
Hydrocarbons - oil	5.9	-1.1
Hydrocarbons - gas	12.6	7.4
Non-energy materials	-62.7	1.1
Food-processing	19.2	-1.8
Textile and leather	89.5	-5.0
Wood working, pulp and paper industry, publishing	52.6	-3.7
Coke products	-61.8	1.8
Petroleum refinement	2.1	-1.0
Chemicals, rubber and plastic products	-85.0	8.7
Other non-metallic mineral products	-19.0	-0.5
Metallurgy and metal processing	-78.6	2.9
Machinery and equipment	74.9	-6.0
Other production	-14.7	-1.1
Electric energy and heat supply	-19.1	0.3
Gas supply	-29.4	1.2
Water supply	-6.8	-0.4
Construction	3.7	-0.9
Trade	-2.6	-1.2
Hotels and restaurants	225.2	-5.0
Transport	-6.3	-0.7
Pipeline transit of oil and gas	-3.8	-1.2
Telecommunication	-4.6	-0.6
Postal services	-4.0	-0.7
Financial intermediation	3.7	-0.8
Real estate transactions	-4.0	-0.6
Renting	4.4	-1.1
Informatisation activities	19.5	-1.6
Research and development	22.0	-1.8
Services to legal entities	10.5	-1.4
Public administration	5.0	-0.7
Education	0.8	-0.5
Health care and social assistance	-0.6	-0.5
Sewage, cleaning of streets and refuse disposal	-6.4	-0.5
Social activities	-13.9	-0.3
Recreational, entertainment, cultural and sporting activities	-4.2	-0.5
Other activities	-8.2	-0.5

Source: author's estimates

Table A2
Percentage change in real domestic supply (cumulative)

	Scenario 1: shock	**Scenario 2:** shock + energy saving
Agriculture, hunting	11.6	-1.3
Forestry	11.0	-1.3
Fishery	9.1	-1.3
Coal and peat	-41.9	1.0
Hydrocarbons - oil	4.8	-1.0
Hydrocarbons - gas	35.2	30.0
Non-energy materials	-64.7	1.8
Food-processing	12.9	-1.5
Textile and leather	105.5	-5.5
Wood working, pulp and paper industry, publishing	40.8	-3.1
Coke products	-64.1	2.1
Petroleum refinement	-0.7	-0.8
Chemicals, rubber and plastic products	-76.3	6.5
Other non-metallic mineral products	-16.0	-0.5
Metallurgy and metal processing	-67.2	2.0
Machinery and equipment	48.7	-4.6
Other production	-10.4	-0.6
Electric energy and heat supply	-18.7	0.3
Gas supply	-29.4	1.2
Water supply	-6.8	-0.4
Construction	3.5	-0.9
Trade	-2.6	-1.2
Hotels and restaurants	46.2	-2.4
Transport	-7.6	-0.6
Pipeline transit of oil and gas		
Telecommunication	-6.9	-0.5
Postal services	-5.8	-0.6
Financial intermediation	3.1	-0.8
Real estate transactions	-5.9	-0.5
Renting	1.4	-1.0
Informatisation activities	5.5	-1.0
Research and development	15.8	-1.5
Services to legal entities	8.6	-1.3
Public administration	4.9	-0.7
Education	0.4	-0.5
Health care and social assistance	-0.9	-0.4
Sewage, cleaning of streets and refuse disposal	-6.4	-0.5
Social activities	-13.9	-0.3
Recreational, entertainment, cultural and sporting activities	-4.4	-0.4
Other activities	-8.3	-0.5

Source: author's estimates

Table A3
Percentage change in real exports (cumulative)

	Scenario 1: shock	**Scenario 2:** shock + energy saving
Agriculture, hunting	56.1	-3.2
Forestry	97.8	-4.4
Fishery	37.9	-3.0
Coal and peat	-15.8	-1.4
Hydrocarbons - oil	10.9	-1.2
Hydrocarbons - gas	-49.3	-55.0
Non-energy materials	-59.7	0.0
Food-processing	44.7	-3.1
Textile and leather	79.6	-4.7
Wood working, pulp and paper industry, publishing	74.2	-4.7
Coke products	-47.4	-0.3
Petroleum refinement	7.9	-1.4
Chemicals, rubber and plastic products	-90.1	9.8
Other non-metallic mineral products	-32.2	-0.5
Metallurgy and metal processing	-82.6	3.1
Machinery and equipment	95.4	-7.2
Other production	-19.5	-1.7
Electric energy and heat supply	-43.0	1.2
Gas supply		
Water supply		
Construction	26.5	-2.5
Trade	30.0	-3.1
Hotels and restaurants	336.7	-6.8
Transport	10.3	-2.2
Pipeline transit of oil and gas	-3.8	-1.2
Telecommunication	37.0	-2.8
Postal services	33.9	-2.8
Financial intermediation	47.6	-2.9
Real estate transactions	25.9	-2.4
Renting	39.4	-2.9
Informatisation activities	63.5	-3.5
Research and development	66.2	-3.8
Services to legal entities	55.5	-3.4
Public administration	46.9	-3.0
Education	44.5	-2.9
Health care and social assistance	35.0	-2.6
Sewage, cleaning of streets and refuse disposal		
Social activities		
Recreational, entertainment, cultural and sporting activities	34.1	-2.6
Other activities	19.8	-2.3

Source: author's estimates

Table A4
Percentage change in real imports (cumulative)

	Scenario 1: shock	**Scenario 2:** shock + energy saving
Agriculture, hunting	-8.6	-0.2
Forestry	-21.3	0.6
Fishery	-5.3	-0.4
Coal and peat	-53.4	2.4
Hydrocarbons - oil	1.7	-1.0
Hydrocarbons - gas	-4.7	-4.0
Non-energy materials	-67.3	2.9
Food-processing	-36.1	2.5
Textile and leather	-4.0	-0.5
Wood working, pulp and paper industry, publishing	-2.1	-0.3
Coke products	-71.4	3.6
Petroleum refinement	-5.1	-0.5
Chemicals, rubber and plastic products	4.7	-0.2
Other non-metallic mineral products	27.0	-0.2
Metallurgy and metal processing	4.4	-0.8
Machinery and equipment	-8.5	0.1
Other production	-4.2	0.0
Electric energy and heat supply	0.6	-0.3
Gas supply		
Water supply		
Construction	-8.3	0.1
Trade	-18.1	-0.1
Hotels and restaurants	-24.1	0.4
Transport	-10.8	-0.2
Pipeline transit of oil and gas		
Telecommunication	-16.8	0.1
Postal services	-23.8	0.7
Financial intermediation	-7.6	-0.2
Real estate transactions	-20.9	0.6
Renting	-16.2	0.2
Informatisation activities	-9.1	-0.2
Research and development	-6.8	-0.1
Services to legal entities	-12.5	0.0
Public administration	-14.3	0.8
Education	-19.3	1.0
Health care and social assistance	-17.7	0.9
Sewage, cleaning of streets and refuse disposal		
Social activities		
Recreational, entertainment, cultural and sporting activities	-22.0	0.9
Other activities		

Source: author's estimates